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Harvesting Costs For Mechanized Thinning Systems In Slash Pine Plantations

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Summary

Harvesting costs of four tree harvester systems were estimated for row thinning 15-year-old slash pine plantations. Two full-tree harvester systems had lower harvesting costs per cord than shortwood harvester and tree-length harvester systems. The shortwood and tree-length harvester systems had lower manpower requirements, but their high capital cost in relation to output resulted in higher harvesting costs when compared to the full-tree harvester systems.

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The vast southern pine plantation acreage now in need of its first commercial thinning has spurred the development of specialized tree harvesting machines. Currently, tree harvesters are mainly used on company operations of pulp and paper firms owning large acreages of plantations. However, independent contractors, who do most of the timber harvesting in the South, must also adopt such machines if thinning requirements are to be met. Furthermore, many contractors are located in areas where plantations are concentrated and will likely be the most commonly available stumpage.

Production and cost information are needed for selecting the most suitable machines for specialized thinning operations. This report estimates harvesting costs for four tree harvester systems designed to row thin slash pine plantations. These estimates can be used to compare systems or to determine economical thinning opportunities for a given system.

Systems and Procedures

Tree harvesters may be classified into three general types according to the form of their output-shortwood, tree-length, and full-tree. That is, the output from the machines will be a bunch of bolts (shortwood), bunched tree-length logs (tree-length), or bunched trees (full-tree). Because the functions performed by each type of harvester are different, measures of output and cost are not directly comparable among the machines. However, the harvesters can be compared by considering them as a part of systems that carry wood to a common delivery point. Evaluation of the systems takes into account the supporting equipment and labor needed with each type of harvester. Evaluating the harvesters on a systems basis also makes possible comparisons of proposed harvesting systems with existing ones.

The following thinning systems were selected to permit estimates of investment, harvesting cost, and productivity:

A) shortwood havester/forwarding/shortwood hauling

B) tree-length harvester/grapple skidding/tree-length hauling

C) full-tree harvester/chain saw limbing and topping/grapple skidding/tree-length hauling

D) full-tree harvester/chain saw limbing and bucking/forwarding/shortwood hauling.

These options are typical combinations with each of the harvesters. Two options for processing and handling wood with the full-tree harvester were selected, since further processing of bunched trees is required with this machine.

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The procedures used for determining system requirements and estimating harvesting costs were the same for all systems. Output rates of the harvesters were obtained for row thinning slash pine plantations and were adjusted to reflect the same performance criteria. Harvester output determined the supporting equipment and men added to complete each system. Assumptions made for skidding and hauling distances and for computing labor and equipment costs were the same for all systems.

System Requirements

Any harvesting system should be designed around the most expensive or key piece of equipment. In a mechanized thinning system, the production of the harvester controls the output rate of the total operation. Therefore, productivity rates of the harvesters can be used to determine the additional equipment and men needed to make-up a system.

Productivity estimates for machines representative of the three types of harvesters being evaluated have been reported for row thinning slash pine plantations (Anderson and Granskog 1974). Table 1 shows hourly production rates, by harvester type, for selected stand conditions in 15-year-old plantations, a common age for thinning. These production figures, however, represent potential output without allowance for downtime or idle time. For this analysis, a 75-percent utilization standard is assumed for each harvester.

To complete each system, supporting equipment and men were selected by determining for each function the number of units required to handle the daily output produced by the harvesters. To insure that harvester output was the limiting factor, the stand condition where production was greatest — site index 70 with 500 trees per acre-was the output level for determining supporting requirements. With the utilization factor applied, these production levels on a daily basis are shortwood, 24.2 cords; tree-length, 35.4 cords;

Table 1.—*Tree harvester productivity for selected stand conditions in 15-year-old slash pine plantations*[1]

Site index	Total trees per acre	Harvester type		
		Shortwood[2]	Tree-lengths[3]	Full-treed[4]
		Cords per hour		
60	500	3.49	4.73	8.87
	600	3.40	4.19	7.96
	700	3.35	4.04	7.87
	800	3.21	3.67	7.79
70	500	4.04	5.87	9.99
	600	4.01	5.13	8.84
	700	3.90	4.72	8.20
	800	3.75	4.27	8.06

[1] Anderson and Granskog 1974.
[2] 7-foot bolts in approximately 1/3-cord piles.
[3] Bunched tree-length logs, 4-5 trees per bunch.
[4] Bunched trees, 4 trees per bunch.

and full-tree, 59.9 cords. Production rates for skidding, loading, and hauling equipment were then compared with these levels to determine the number of units required.

Total system requirements are summarized in figure 1. Skidding of 660 feet and hauling distances of 30 miles were assumed in all cases. Separate loaders are required in two systems to place tree-length material on hauling units; shortwood is unloaded by the prehaulers directly onto set-out trailers. More trucks are needed to transport tree-length material than shortwood because the short length of plantation stems does not fully utilize trailer capacity. Trucking requirements were based upon 7-cord loads for tree-lengths and lo-cord loads for shortwood.

In the shortwood and tree-length harvester systems, felling and processing are completed by the harvesting machines. The two systems incorporating the full-tree harvester require chain saw operators for processing the bunched trees. It is estimated that two men would be needed to limb and top tree-length logs, and four men would be required for limbing and bucking 7-foot shortwood.

Production manpower requirements for each system, following the letter designations in fig. 1, are: A-3 men, B-4 men, C—8 men, and D-9 men. Tree-length wood is loaded by the truck drivers.

System Costs

Harvesting cost estimates for each system may be computed by calculating hourly system costs and using production rates from table 1 with adjustment for the 75-percent utilization standard assumed.

A synopsis of system costs is contained in table 2. Investment figures are based on prices of new machines in 1977, except it was assumed that tree-length loaders would be mounted on used trucks. Major assumptions for computing machine costs were 5-year depreciation for all equipment (except l-year depreciation for chain saws), 20 percent salvage value, and 14 percent of the average annual investment for interest, insurance, and taxes. Repair and maintenance charges were 100 percent of the purchase price. Fuel, oil, and lubrication costs were also included. Labor costs were determined by multiplying the number of men required in each system by a $5.50 per hour cost, which included wages and charges for social security, workers' compensation, and unemployment insurance.

Table 2. *-System costs*

System	Initial investment	Hourly costs		
		Machine	Labor	Total
A	$148,700	$37.92	$16.50	$ 54.42
B	198,500	52.39	22.00	74.39
C	203,200	58.64	44.00	102.64
D	173,200	50.13	49.50	99.63

SYSTEM	FUNCTIONAL REQUIREMENTS							
A	1 shortwood harvester	→	1 prehauler	→	1 truck, 3 set-out trailers			
B	1 tree-length harvester	→	1 grapple skidder	→	1 loader	→	2 trucks 2 trailers	
C	1 full-tree harvester	→	2 chain saw operators (limb & top)	→	2 grapple skidders	→	1 loader	→ 3 ~~2~~ trucks 3 trailers
D	1 full-tree harvester	→	4 chain saw operators (limb & buck)	→	2 prehaulers	→	2 trucks 5 set-out trailers	

Figure 1.—*Systems components*

Table 3.-*Estimated harvesting costs per cord of four tree-harvester systems for selected stand conditions in 15-year-old slash pine plantations*

Site index	Total trees per acre	Harvesting systems A	B	C	D
		Cost per cord			
60	500	$20.77	$20.95	$15.43	$14.98
	600	21.34	23.69	17.19	16.69
	700	21.68	24.55	17.40	16.87
	800	22.58	27.05	17.58	17.06
70	500	17.96	16.91	13.70	13.30
	600	18.08	19.32	15.48	15.03
	700	18.57	21.01	16.69	16.20
	800	19.37	23.25	16.97	16.47

Cost-per-cord estimates (table 3) were obtained by dividing hourly system costs (machine plus labor) by hourly system outputs (harvester production rates adjusted for 75-percent utilization) for the selected stand conditions. Stumpage and administrative expenses are not included in the cost-per-cord estimates. Manpower productivity figures are shown in table 4.

For all systems, productivity decreases and harvesting costs increase as site index drops from 70 to 60 and stand density increases. This is because tree size declines as site index decreases and stand density increases.

Both full-tree harvester systems cost less per cord than the shortwood harvester and tree-length harvester systems, even though the latter two are more advantageous in man-day productivity. Although the shortwood and tree-length machines reduce manpower requirements, the high capital cost in relation to their output compares unfavorably with the full-tree harvester systems. The capability of the full-tree machine to put considerably more wood on the ground and allow processing of bunched stems by chain saw operators results in lower harvesting costs.

Table 4.—*Output per man-day of four tree harvester systems for selected stand conditions in 15 year-old-slash pine plantations*

Site index	Total trees per acre	Harvesting system A	B	C	D
		Cords per man-day			
60	500	7.0	7.1	6.6	5.9
	600	6.8	6.3	6.0	5.3
	700	6.7	6.1	5.9	5.2
	800	6.4	5.5	5.8	5.2
70	500	8.1	8.8	7.5	6.7
	600	8.0	7.7	6.6	5.9
	700	7.8	7.1	6.2	5.5
	800	7.5	6.4	6.0	5.4

Discussion

From the standpoint of harvester selection, the cost per cord estimates presented here indicate a full-tree harvester has an advantage over other types of harvesters for the stand conditions considered, whether it is combined with shortwood or tree-length supporting equipment. When upgrading an existing system, a full-tree machine would be favored to go with either type of supporting equipment that is being used.

Assembling a new system would permit a choice in the type of supporting machines used with the harvester. Although the shortwood option has slightly lower costs among the two alternatives examined, the cost-per-cord estimates for the conditions considered were based on fixed skidding and hauling distances. The effect on total costs as these factors change should be considered in the selection of auxiliary equipment, as well as other factors that may vary between systems.

For example, a prehauler is more cost-effective when long skidding distances are involved because it has a larger capacity than a grapple skidder (typically two cords vs. one cord or less). This offers greater versatility in harvesting small or isolated tracts. Landing costs are minimized with a prehauler system because set-out trailers may be parked along truck roads without construction of a large landing area. A prehauler also can maneuver in a stand with less damage to standing trees than a grapple skidder with a load of tree-length wood.

Alternatively, a grapple skidder with a full-tree harvester may offer more development flexibility. For instance, an iron gate delimber is a simple, cost-effective means of eliminating manual delimbing with a grapple skidder (Bryan 1977). Also, a full-tree harvester/grapple skidder combination can be upgraded into a whole tree chipping operation.

The potential of any harvesting system can be lost by poor planning and administration. A good maintenance program is essential to obtain the machine availability necessary for a successful mechanized operation. Downtime can be minimized by careful planning. For instance, the harvester is the limiting machine in the systems considered. Operating the harvester a few days ahead of the rest of the equipment would help avoid total shutdowns and improve system reliability. The lead time insures a supply of felled wood for other functions when the harvester is idled for repairs.

Adopting a mechanized thinning system, of course, requires a large capital investment. Many independent operators today may not be willing or able to undertake the investment required to perform all of the functions of the harvesting operation. One approach to this problem may be to encourage machine operators who become proficient in a function to purchase their own machines. Truck drivers and harvester and prehauler operators who have the inclination to operate their own businesses could specialize in that capacity for a number of other wood producers.

Literature Cited

Anderson, W. C., and J. E. Granskog
1974. Mechanized row-thinning systems in slash pine plantations. U.S. Dep. Agric. For. Serv. Res. Pap. SO-103, 12 p. South. For. Exp. Stn., New Orleans, La.

Bryan, R. W.
1977. Delimbing gate. For. Ind. 104(7): 93.

Granskog, James E.

1978. Harvesting costs for mechanized thinning systems in slash pine plantations. U.S. Dep. Agric. For. Serv. Res. Pap. SO-141, 7 p.

Harvesting costs of four tree harvester systems are estimated for row thinning slash pine plantations. Systems incorporating a full-tree type harvester had lower harvesting costs per cord than shortwood and tree-length harvester systems in 15-year-old plantations.

Additional keywords: Tree harvesters, mechanization, productivity, and logging costs.